Macroeconomic dynamics in the UK mortgage market

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Motivation

- Inflationary pressures call for **rises in the policy rate** R_t
  * Bank of England have raised their interest rate to 5.25% from 0.1% since December 2021
  * Other central banks have implemented similar measures
- Higher rates affect demand (consumption) and financial stability primarily through the **housing market**
- Importantly, rising mortgage costs affect the economy differently depending on what type of **mortgage contracts** households have
- Typically, there are two types of contracts
  * Fixed rate mortgages $\rightarrow$ high R_t matters for new mortgages and when refinancing
  * Adjustable rate mortgages $\rightarrow$ almost 1 to 1 pass through between R_t and mortgage rate
- But the **UK** (mortgage market) **is different** ...

▷ Bank Rate ▷ Mortgage Rates ▷ Mortgage Spread

What we do

- Empirically:
  * Use Product Sales Data (PSD) on mortgage originations in the UK
  * Describe the distribution of mortgage contracts in the UK (interest rate, duration, etc.)
- Theoretically:
  * Modify Greenwald (2018) macro-housing model to reflect some UK mortgage market features
  * Study the macroeconomic transmission of various shocks under different mortgage contract types: FRM, ARM, Hybrid Rate Mortgage (HRM)
  * Study the effects of the recent increases in the policy rate on real outcomes when mortgage contracts are similar to those hold by UK households

What we find

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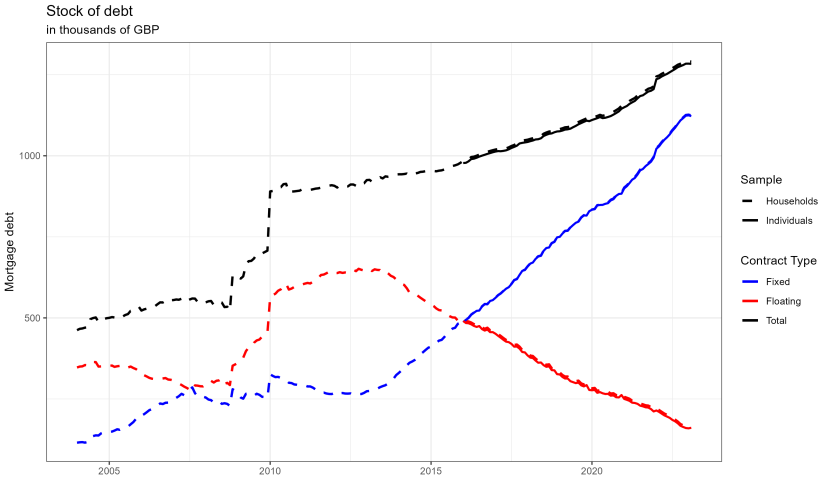
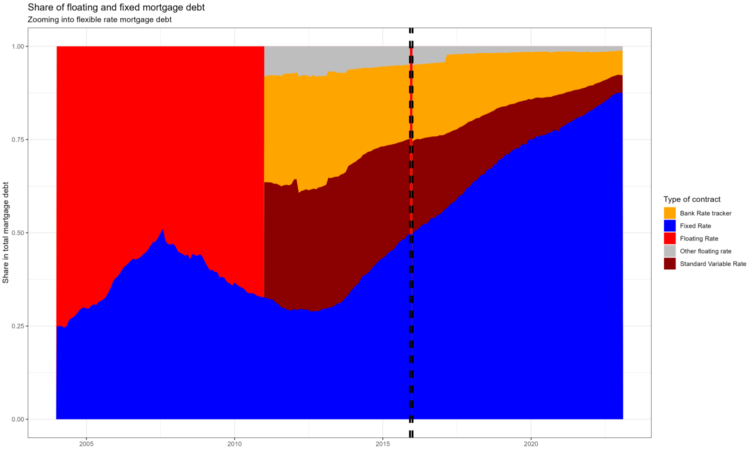
The UK Mortgage Market

The stock of mortgage debt continues to grow

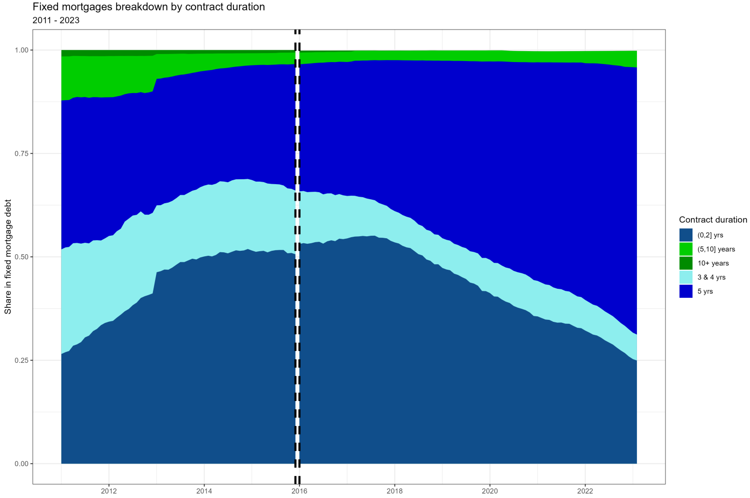


Fixed versus Floating Mortgage Debt

- The share of fixed mortgage debt has steadily increased from 35% of total debt in 2014 to more than 75% in 2023
- The remaining 25% is split between Standard Variable Rate and BoE Bank Rate Tracker



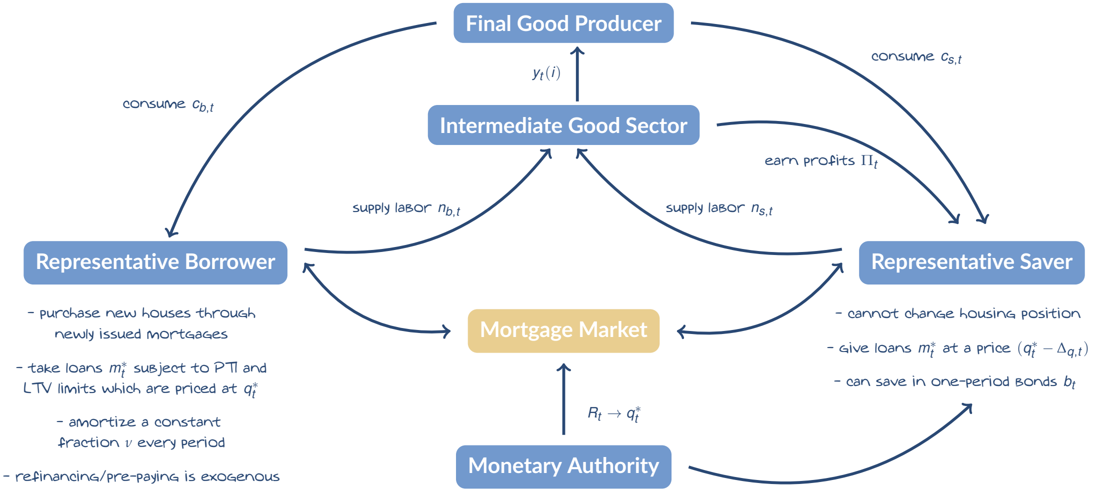
Fixed rate contracts have a short duration



- 2-year and 5-year contracts are the most popular contracts in the UK
- Note that these contracts revert to a floating rate after the fixation period

The Model Economy

Model sketch



Borrower's Problem

- Chooses *consumption* $c_{b,t}$, *labor* supply $n_{b,t}$, the size of newly purchased *houses* $h^*_{b,t}$, and the face value of newly issued *mortgages* m^*_t
- to maximize lifetime expected discounted utility using the aggregate utility function

$$u(c_{b,t}, h_{b,t-1}, n_{b,t}) = \log(c_{b,t}/\chi_b) + \xi \log(h_{b,t-1}/\chi_b) - \eta_b \frac{(n_{b,t}/\chi_b)^{1+\varphi}}{1+\varphi} \tag{1}$$

- subject to the **budget constraint**

$$\begin{aligned} c_{b,t} \leq &(1-\tau_y) w_t n_{b,t} - \pi_t^{-1} \left((1-\tau_y) x_{b,t-1} + \nu m_{t-1}\right) + \rho_b \left(m^*_t - (1-\nu)\pi_t^{-1} m_{t-1}\right) \\ &- \delta p^h_t h_{b,t-1} - \rho_b p^h_t \left(h^*_{b,t} - h_{b,t-1}\right) + T_{b,t} \end{aligned} \tag{2}$$

- the **debt constraint**

$$m^*_t \leq \bar{m}_t = \underbrace{\left(\left(\theta^{PTI} - \omega\right) w_t n_{t,i} e_{t,i}\right) / \left(q^*_t + \alpha\right)}_{=\bar{m}^{PTI}_t} \int^{\bar{e}_t} e_i d\Gamma_e(e_i) + \underbrace{\theta^{LTV} p^h_t h^*_{i,t}}_{=\bar{m}^{LTV}_t} \left(1 - \Gamma_e(\bar{e}_t)\right) \tag{3}$$

- and **laws of motion** for total start-of-period debt balances m_{t-1}, total promised payments on existing debt $x_{t-1} \equiv q_{t-1} m_{t-1}$ and total start-of-period borrower housing $h_{b,t-1}$

Mortgage Debt Balances & Promised Payments

- Two benchmarks:
  * *Fixed rate mortgage contract (FRM)*

$$m_t = \rho_b m_t^* + (1-\rho_b)(1-\nu)\pi_t^{-1} m_{t-1}$$
$$x_{b,t}^{FRM} = \rho_b q_t^* m_t^* + (1-\rho_b)(1-\nu)\pi_t^{-1} x_{b,t-1}$$

  * *Flexible rate mortgage contract (ARM)*

$$m_t = \rho_b m_t^* + (1-\rho_b)(1-\nu)\pi_t^{-1} m_{t-1}$$
$$x_{b,t}^{ARM} = q_t^* m_t$$

- **UK Mortgage Framework** (e.g. 2 periods fixed, then adjustable contract)

$$m_t = \rho_b m_t^* + (1-\rho_b)(1-\nu)\pi_t^{-1} m_{t-1}$$
$$x_{b,t}^{HRM} = \rho_b q_t^* m_t^* + (1-\rho_b)(1-\nu)\pi_t^{-1}\rho_b q_{t-1}^* m_{t-1}^* + (1-\rho_b)^2(1-\nu)^2\pi_t^{-1}\pi_{t-1}^{-1} q_{t-1}^* m_{t-1}$$

▷ General Hybrid Rate Mortgage Contracts

Saver's Problem

- Chooses *consumption* $c_{s,t}$, *labor* supply $n_{s,t}$, one period bonds b_t, and the face value of newly issued *mortgages* m_t^*
- to maximize lifetime expected discounted utility using the aggregate utility function

$$u(c_{s,t}, n_{s,t}) = \log(c_{s,t}/\chi_s) + \xi \log(\tilde{H}_{s,t-1}/\chi_s) - \eta_s \frac{(n_{s,t}/\chi_s)^{1+\varphi}}{1+\varphi} \tag{4}$$

- subject to the **budget constraint**

$$\begin{aligned} c_{s,t} \leq (1-\tau_y)\, w_t n_{s,t} + \pi_t^{-1} x_{s,t-1} - \rho_b \left(m_t^* - (1-\nu)\pi_t^{-1} m_{t-1} \right) \\ - \delta p_t^h \tilde{H}_s - \left(R_t^{-1} b_t - \pi_t^{-1} b_{t-1} \right) + \Pi_t + T_{s,t} \end{aligned} \tag{5}$$

- and **laws of motion** for total start-of-period debt balances m_{t-1}, and total promised payments on existing debts:

$$x_{s,t}^{FRM} = \rho_b \left(q_t^* - \Delta_{q,t} \right) m_t^* + (1-\rho_b)(1-\nu)\pi_t^{-1} x_{s,t-1} \quad \text{or} \quad x_{s,t}^{ARM} = \left(q_t^* - \Delta_{q,t} \right) m_t \tag{6}$$

where $\Delta_{q,t}$ is a proportional tax on all future mortgage payments that follows a stochastic process (term premium shock = innovation on the process)

The rest of the economy

- **Production**
  * A competitive *final good producer*: $\max_{y_t(i)} P_t \left[\int_0^1 y_t(i)^{\frac{\lambda-1}{\lambda}} di\right]^{\frac{\lambda}{\lambda-1}} - \int_0^1 P_t(i) y_t(i) di$
  * A continuum of *intermediate good producers* that choose price $P_t(i)$ and operates a linear technology $y_t(i) = a_t n_t(i)$ to meet the final's good producer demand.
  * Intermediate good producers are subject to *price stickiness* – Calvo pricing with indexation.
- **Monetary authority**: it follows a *Taylor rule* of the form

$$\begin{aligned} \log R_t = \log \bar{\pi}_t &+ \phi_r \left(\log R_{t-1} - \log \bar{\pi}_{t-1}\right) \\ &+ (1 - \phi_r) \left[\left(\log R_{ss} - \log \pi_{ss}\right) + \psi_\pi \left(\log \pi_t - \log \bar{\pi}_t\right)\right] \end{aligned} \tag{7}$$

where $\bar{\pi}_t$ is a time-varying inflation target

Equilibrium Conditions

Mortgage Pricing

- The optimality of new debt, m_t^*, determines the mortgage coupon rate, q_t^*.
- **Borrower optimality**:

$$1 = \Omega^m_{b,t} + \Omega^x_{b,t} q_t^* + \mu_t \tag{8}$$

where μ_t is the multiplier on the aggregate credit limit, and $\Omega^m_{b,t}$ and $\Omega^x_{b,t}$ are the marginal continuation *costs* to the the borrower of taking an additional dollar of face value debt and of promising an additional dollar of initial payments

- **Saver optimality**:

$$1 = \Omega^m_{s,t} + \Omega^x_{s,t} \left(q_t^* - \Delta_{q,t} \right) \tag{9}$$

where $\Omega^m_{s,t}$ and $\Omega^x_{s,t}$ are the marginal continuation *benefits* of an additional unit of face value debt and an additional dollar of promised initial payments

- **Borrower (saver) marginal continuation costs (benefits) differ depending on the contract type: (a) FRM, (b) ARM, (c) HRM**

Mortgage Pricing II – borrower's continuation costs

- Fixed Rate Mortgage Contracts

$$\Omega^m_{b,t} = \mathbb{E}_t \left[\Lambda^b_{t,t+1} \pi^{-1}_{t+1} \left(\nu + (1-\nu)\, \rho_{t+1} + (1-\nu)(1-\rho_{t+1}) \Omega^m_{b,t+1} \right) \right] \tag{10}$$

$$\Omega^x_{b,t} = \mathbb{E}_t \left[\Lambda^b_{t,t+1} \pi^{-1}_{t+1} \left((1-\tau_y) + (1-\nu)(1-\rho_{t+1}) \Omega^x_{b,t+1} \right) \right] \tag{11}$$

- Adjustable Rate Mortgage Contracts

$$\Omega_{b,t} = \mathbb{E}_t \left[\Lambda^b_{t,t+1} \pi^{-1}_{t+1} \left((1-\tau_y)\, q^*_t + \nu + (1-\nu)\, \rho_{t+1} + (1-\nu)\,(1-\rho_{t+1})\, \Omega_{b,t+1} \right) \right] \tag{12}$$

$$\Omega^x_{b,t} = 0 \tag{13}$$

- **Hybrid Rate Mortgage Contracts**

$$\Omega^m_{b,t} = \mathbb{E}_t \left[\Lambda^b_{t,t+1} \pi^{-1}_{t+1} \left(\nu + (1-\nu)\, \rho_{t+1} + (1-\nu)(1-\rho_{t+1}) \Omega^m_{b,t+1} \right) \right] \tag{14}$$

$$\Omega^x_{b,t} = \mathbb{E}_t \left[\Lambda^b_{t,t+1} \pi^{-1}_{t+1} (1-\tau_y) \right] + \sum_{\tau=1}^{T-1} \mathbb{E}_{t+\tau} \left[\Lambda^b_{t,t+1} \pi^{-1}_{t+1} \left(\prod_{j=1}^{\tau} \Lambda^b_{t+1+j,t+j} \pi^{-1}_{t+1+j} (1-\rho_{t+j}) \right) (1-\tau_y) \right] \tag{15}$$

▷ Saver's continuation benefits

Interest Rate Transmission

What have we learned from Greenwald (2018)?

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- ***Constraint Switching Effect*** ▷ Go to IRFs
  * The interaction of LTV and PTI constraints creates a transmission chain from interest rates into house prices and amplifies the debt response
    - A reduction in rates directly loosens the PTI constraint which in turn increases the share of LTV-constrained borrowers
    - These borrowers can increase their borrowing limit with additional collateral which boosts housing demand, rising the price-to-rent ratio
    - Higher house price increase collateral values, relaxing LTV constraints, and leading to a larger response of debt
- *Frontloading Effect* ▷ Go to IRFs
  * Looser credit conditions (e.g. lower mortgage rates) lead to a large increase in borrower consumption as they refinance more quickly
  * As a result, output rises in the short run before intermediate firms reset their prices

FRM vs. ARM

- ***Transitory shocks*** ▷ Go to IRFs
  * *Term premium shock* imposes a temporary shift in mortgage rates
  * **Under FRM** borrowers *refinance* and take *larger loans* to secure cheaper credit, leading to
    - a 2.5 larger mortgage debt increase after 2 years, . . .
    - a 35% larger price to rent ratio upon impact, and
    - a 6% bigger output response on impact than under ARM
  * *Redistribution* from savers to borrowers is **larger under FRM**
  * *Endogenous refinancing* amplifies household consumption, output and inflation responses only under FRM
    - For a constant refinancing rate $\rho = 0.145$, output and inflation responses are similar under both contracts
- ***Permanent shocks*** ▷ Go to IRFs
  * *Inflation target shock* imposes a near permanent change in mortgage rates
  * *Aggregate variable responses* are **similar** across contract types
  * *Redistribution* from savers to borrowers **larger under ARM** (except from $t = 0$)

UK interest rate transmission

- Recall that typical contract in UK mortgage market features fixed mortgage rates for a short (2-5 year) duration after reverting to a variable rate
- A first pass would be to study an economy with **high refinancing rates** and **fixed rate mortgages**. Two approaches:
  * *Reduce refinancing costs* while keeping endogenous choice
    - Leads to a larger pre-payment rates, more debt and higher prices-to-rent ratio ▷ Go to figure
    - But it is inconsistent with the UK framework as fees are prohibitive during the fixation period
  * **Making the *refinancing* decision *exogenous***
    - Exogenous prepayment downplays the differential response of consumption, output and inflation to *transitory shocks* in the FRM vs. ARM economies ▷ Go to IRFs
    - The responses to *permanent shocks* in the FRM vs. ARM economies are similar despite the higher refinancing rates ▷ Go to IRFs
    - Berger et al. (2021) show that refinancing rates are fairly constant when rates gap are negative. This is typically the case in hike cycles. Supportive evidence for exogenous pre-payment

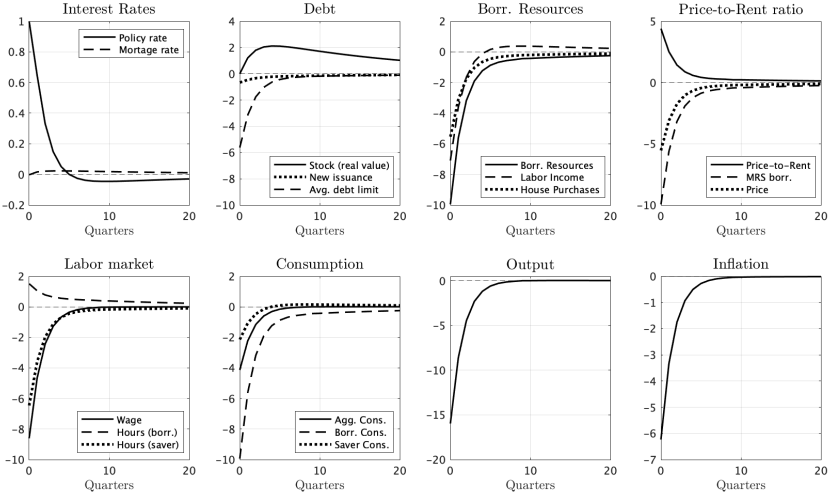
▷ Steady State & Refi Rate

Interest Rate Hikes – Monetary Policy Shock

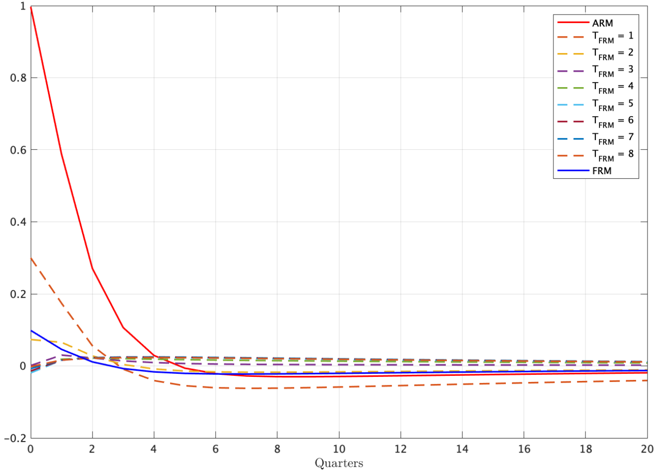
- **Conventional monetary policy** (policy rate movements) affects mortgage rates differently depending on the *mortgage contract* (FRM vs ARM) and *refinancing rate* ▷ Go to figure
  * One-to-one pass-through for ARM, independently of the refinancing rate
  * Pass-through is increasing in the refinancing rate for FRM, but always below one-to-one
- For a **FRM economy** with a refinancing rate of $\rho_b = 0.145$, a 1% increase in the policy rate leads to
  * an immediate **fall in the inflation rate** because the economy slows down as households cut on consumption, with **borrower's consumption falling by more** than that of savers
  * deflation leads to in ***increase* in the real value of debt** despite a decrease in loan's size associated with higher mortgage rates
  * **more expensive credit reduces housing demand** and house price falls, however, the price to rent ratio rises
- For a **ARM economy**, the same 1% increase in the policy rate results in similar quantitative and qualitative responses despite the **larger increase in mortgage payments**
  * Implication: New Keynesian channel dominates (see Garriga et al., 2021)

▷ FRM IRFs ▷ ARM IRFs

Hybrid Rate Mortgages (2yr HRM)



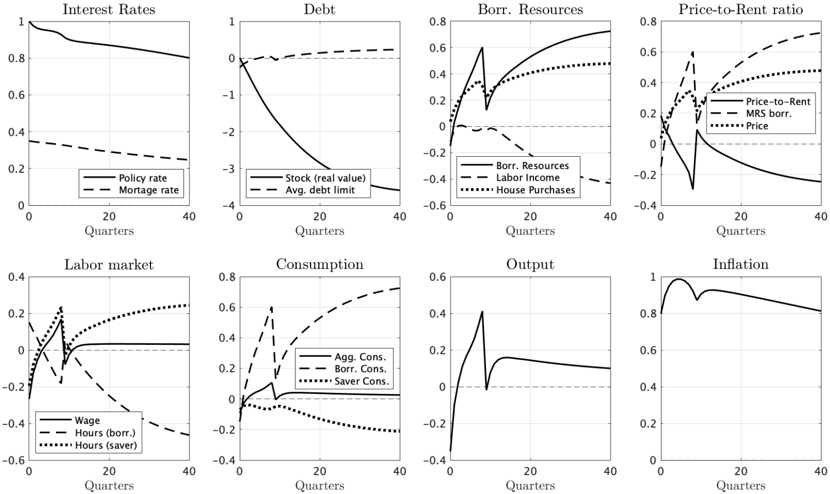
Pass-Through in HRM with different durations



Interest Rate Hikes – Inflation Traget Shock

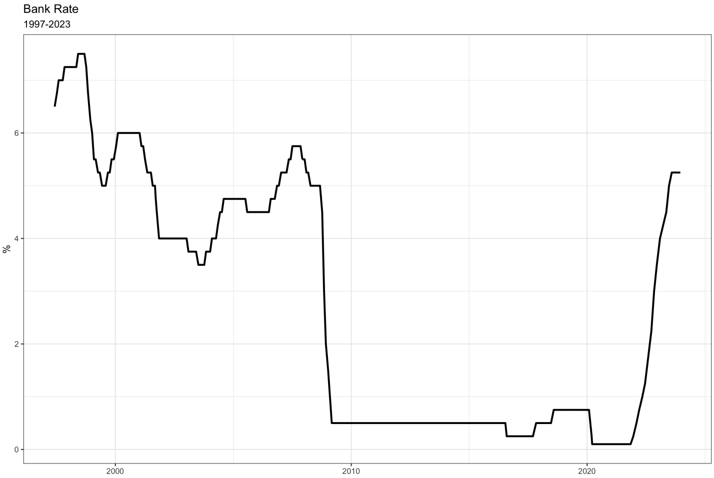
▷ FRM IRFs ▷ ARM IRFs

Hybrid Rate Mortgages (2yr HRM)



Appendix

Bank Rate



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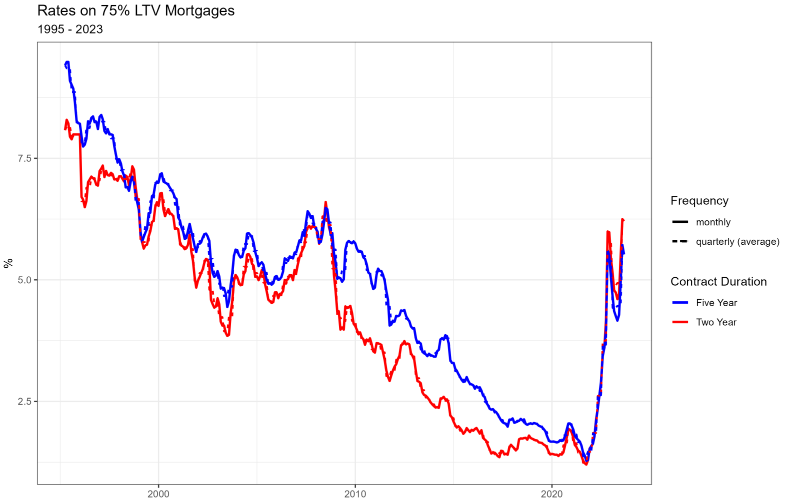
Mortgage Rates



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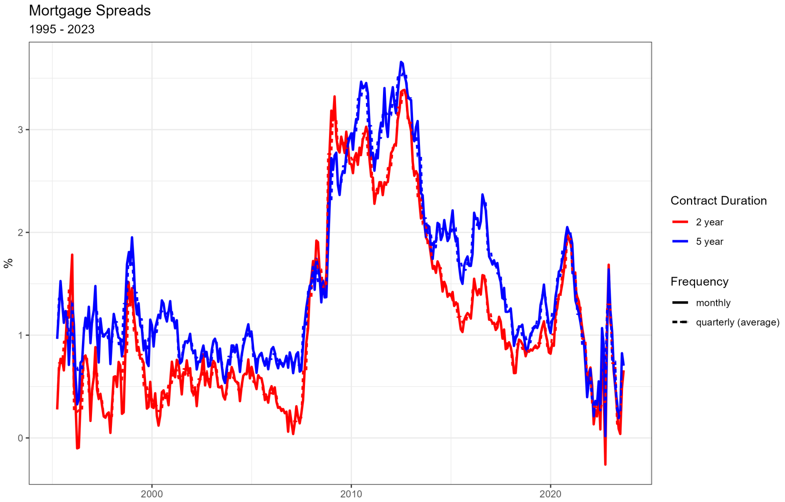
Mortgage Spreads



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Hybrid mortgages

- Typical UK mortgage contracts are hybrid between ARM and FRM. They are T periods under fixed rates before switching to an adjustable one
- Hybrid Rate Mortgages can be generalized to embrace these two contracts
  * ARM $\equiv$ HRM with $T = 0$
  * FRM $\equiv$ HRM with $T = \infty$
- In general, for a T-period adjustable mortgage, the low of motion of promised payments is:

$$
\begin{aligned}
x_{b,t}^{HRM} = & \rho_b q_t^* m_t^* + \left[\sum_{\tau=1}^{T-1} \left(\prod_{i=0}^{\tau-1} (1-\rho_b)(1-\nu)\pi_{t-i}^{-1} \right) \rho_b q_{t-\tau}^* m_{t-\tau}^* \right] + \\
& + \left(\prod_{i=0}^{T-1} (1-\rho_b)(1-\nu)\pi_{t-i}^{-1} \right) q_{t-T}^* m_{t-T}
\end{aligned}
$$

▷ Back

Saver's Continuation Benefits

- Fixed Rate Mortgage Contracts

$$\Omega^{m}_{s,t} = \mathbb{E}_t \left[\Lambda^{s}_{t,t+1} \pi^{-1}_{t+1} \left(\rho_b \left(1-\nu\right) + (1-\rho_b)(1-\nu)\Omega^{m}_{s,t+1} \right) \right] \tag{16}$$

$$\Omega^{x}_{s,t} = \mathbb{E}_t \left[\Lambda^{s}_{t,t+1} \pi^{-1}_{t+1} \left(1 + \left(1-\rho_b\right) \left(1-\nu\right) \Omega^{x}_{s,t+1} \right) \right] \tag{17}$$

- Adjustable Rate Mortgage Contracts

$$\Omega_{s,t} = \mathbb{E}_t \left[\Lambda^{s}_{t,t+1} \pi^{-1}_{t+1} \left(\left(q^{*}_{t} - \Delta_{q,t} \right) + \left(1-\nu\right) \rho_b + (1-\nu)(1-\rho_b)\Omega_{s,t+1} \right) \right] \tag{18}$$

$$\Omega^{x}_{b,t} = 0 \tag{19}$$

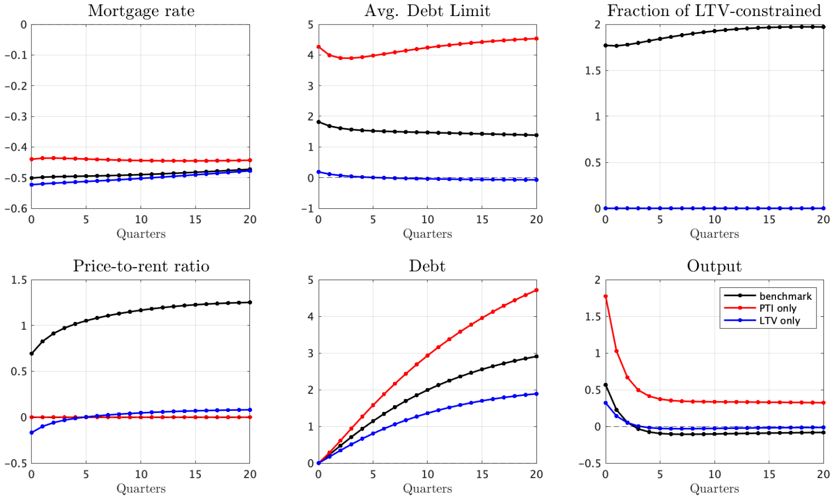
- **Fixed Period Adjustable Mortgage Contracts**

$$\Omega^{m}_{s,t} = \mathbb{E}_t \left[\Lambda^{s}_{t,t+1} \pi^{-1}_{t+1} \left(\rho_b \left(1-\nu\right) + (1-\rho_b)(1-\nu)\Omega^{m}_{s,t+1} \right) \right] \tag{20}$$

$$\Omega^{x}_{b,t} = \mathbb{E}_t \left[\Lambda^{b}_{t,t+1} \pi^{-1}_{t+1} \right] + \sum_{\tau=1}^{T-1} \mathbb{E}_{t+\tau} \left[\Lambda^{b}_{t,t+1} \pi^{-1}_{t+1} \left(\prod_{j=1}^{\tau} \Lambda^{b}_{t+1+j,t+j} \pi^{-1}_{t+1+j} (1-\rho_b)(1-\nu) \right) \right] \tag{21}$$

▷ Back

Constraint Switching Effect – Inflation Target Shock



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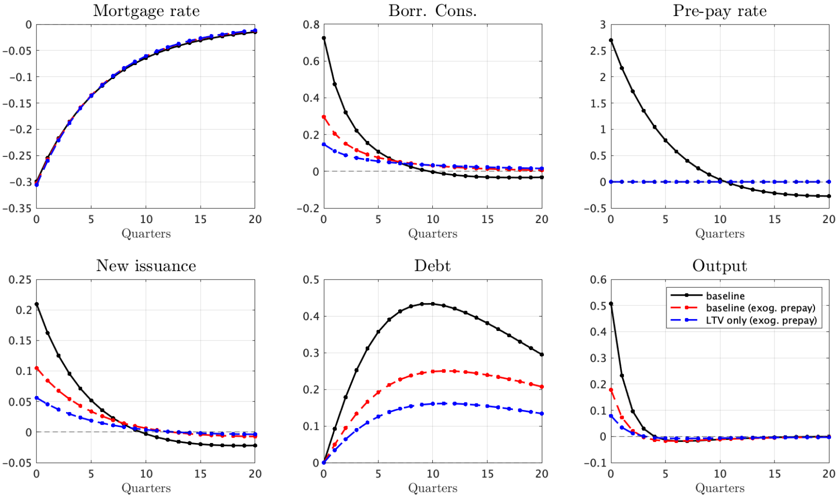
Frontloading Effect – Term Premium Shock



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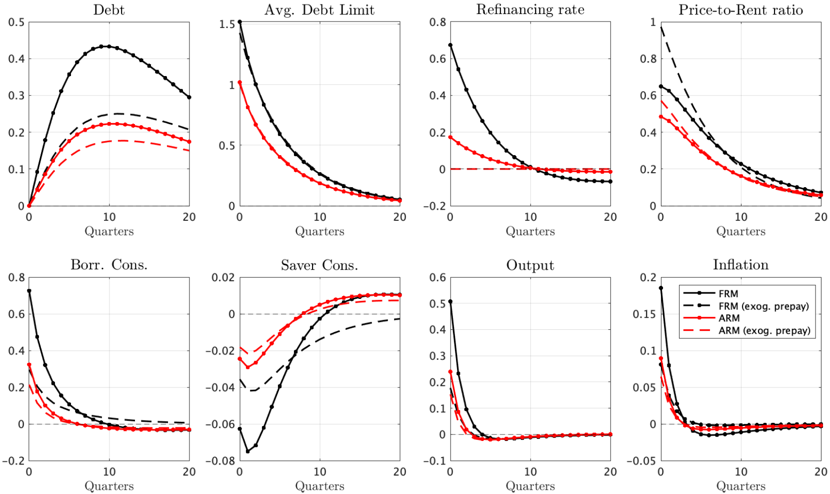
Transitory Shock – FRM vs ARM



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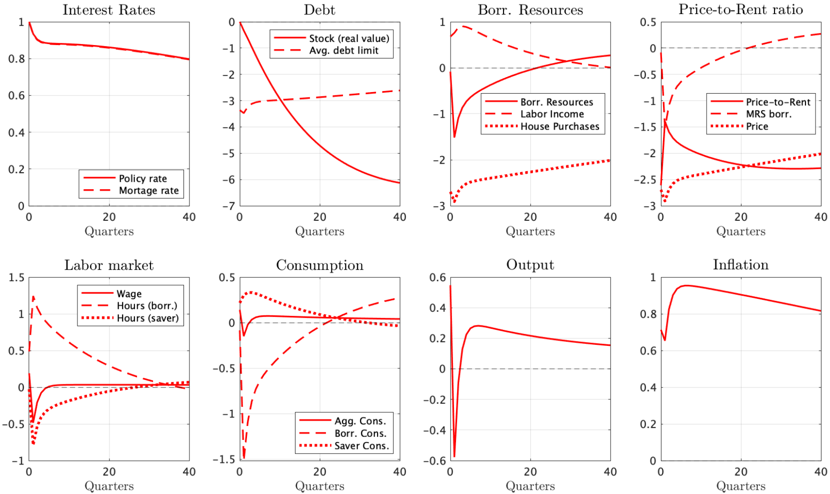
Permanent Shock – FRM vs ARM



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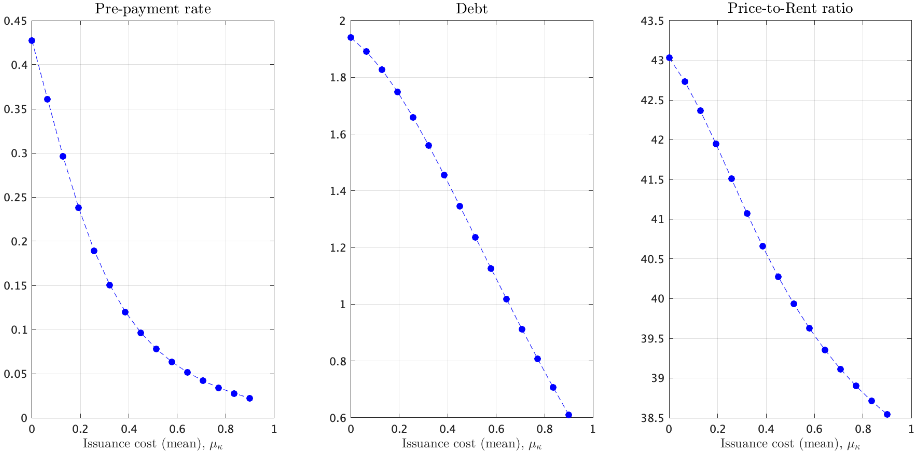
Issuance costs



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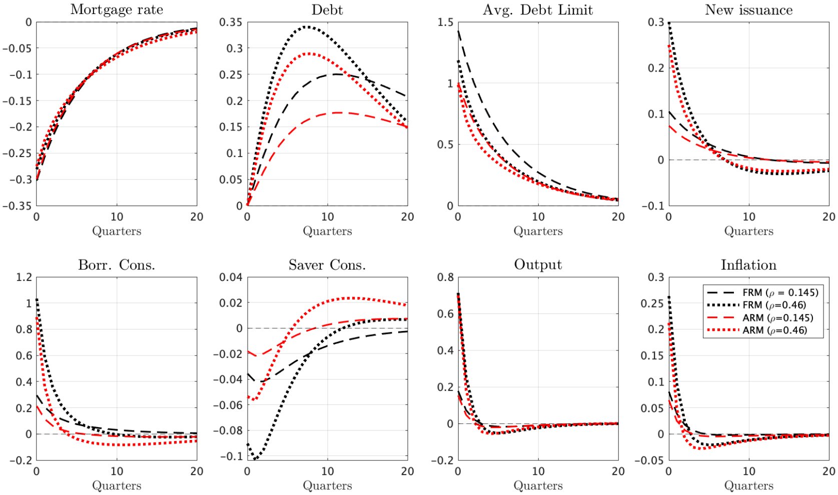
High vs. Low Refinancing Rate – Temporary Shock



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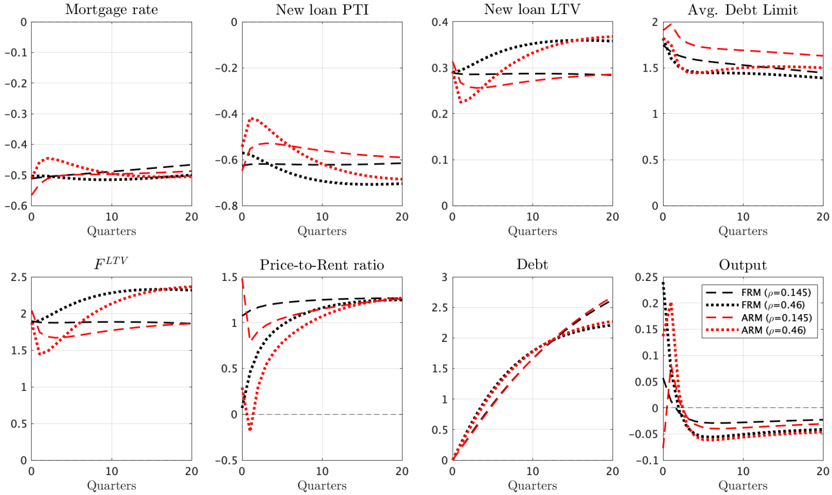
High vs. Low Refinancing Rate – Permanent Shock



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How does ρ_b affect steady state aggregates?

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- An **increase** in the exogenous refinancing rate ρ_b leads to:
    * Higher levels of mortgage debt via new issuance and bigger loans ▷ Go to figure
    * More housing demand, which puts upward pressure in the house price to rent ratio and loosens the LTV limit ▷ Go to figure
    * A redistribution of resources from borrowers to savers despite not affecting the equilibrium mortgage coupon ▷ Go to figure

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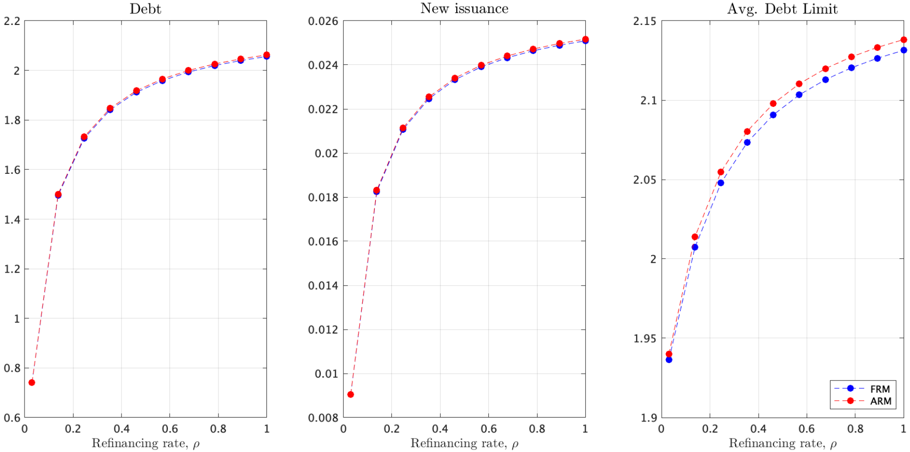
More refinancing leads to more debt



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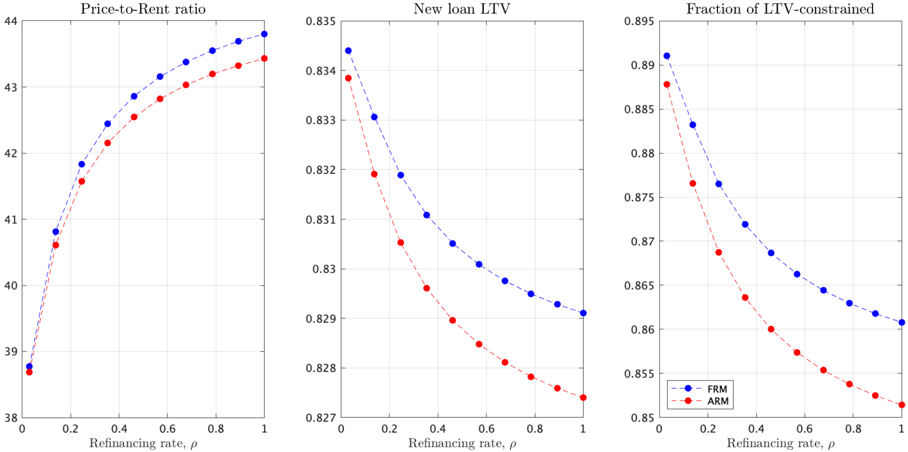
More refinancing boosts housing demand



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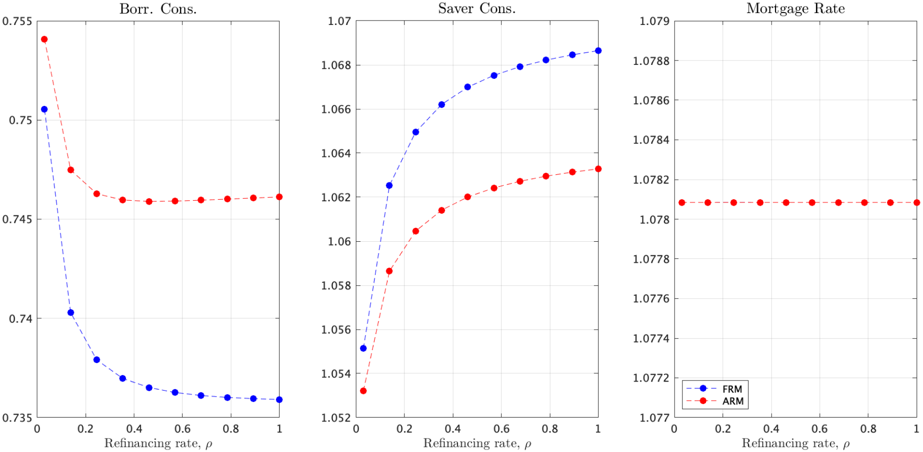
More refinancing redistributes from borr. to savers



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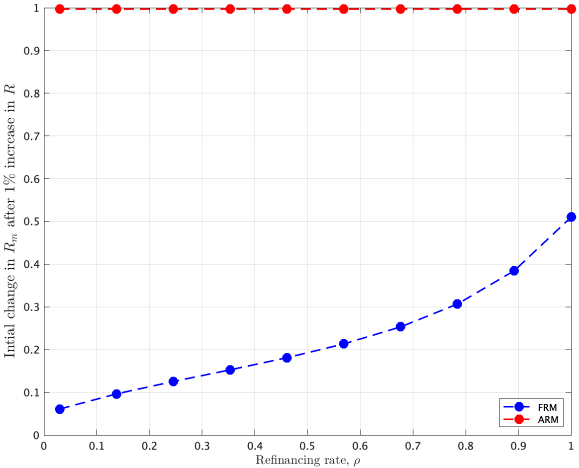
Monetary Policy Pass-Through to Mortgage Rates



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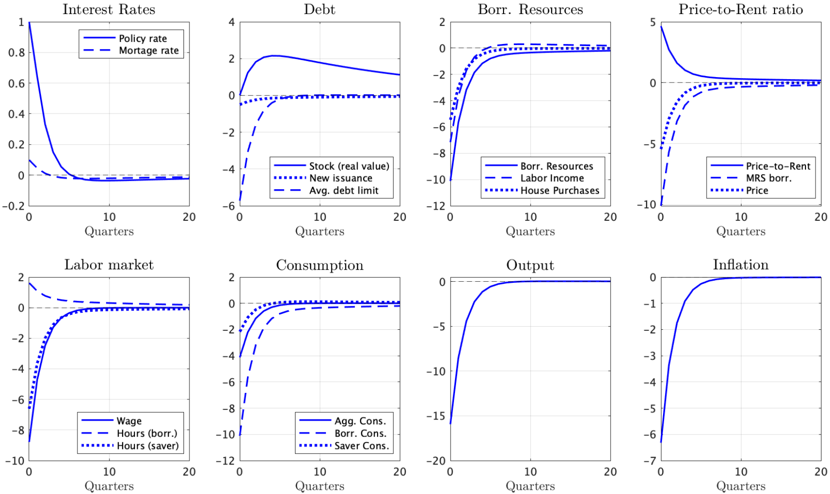
Temporary Monetary Shock in FRM economy



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Temporary Monetary Shock in FRM economy

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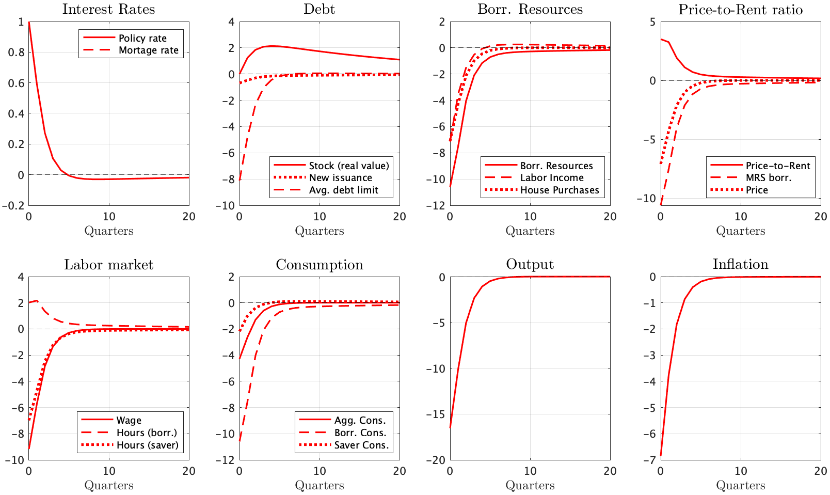

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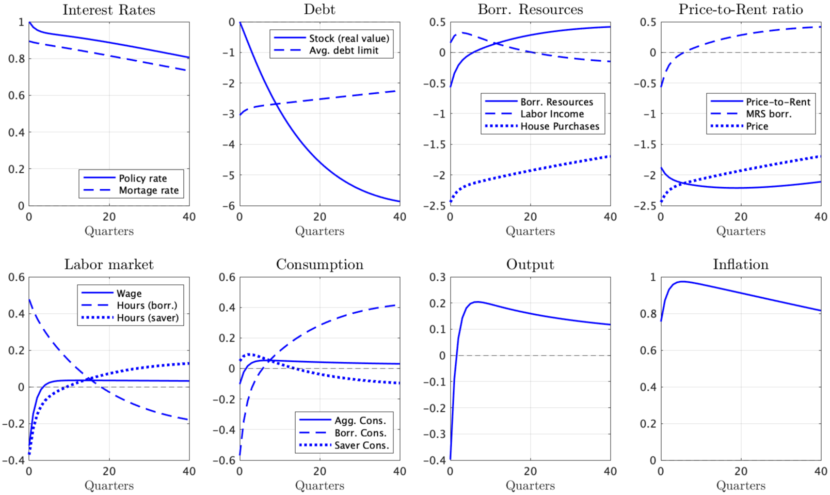
Inflation Target Shock in FRM economy



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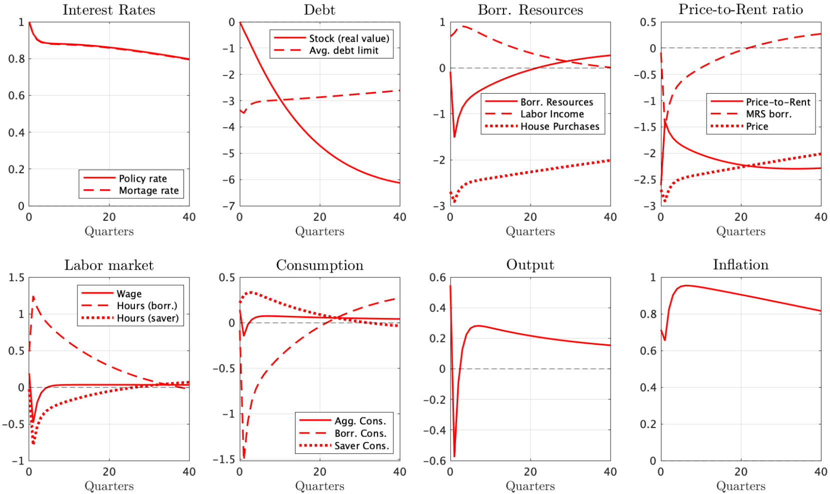
Inflation Target Shock in FRM economy



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